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Title: RA EIS Corridor Analysis for Engineering Input for Part 1 Technical Memo 04/11/07

Supplier Document #: NRP-R-SYSW-EI-0005-01

Supplier Rev.: 01

Supplier Date: 4/11/07

NVM Nevada Transportation Manager Gene Allen
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Nevada Rail Partners NRP	NN-HC4-00239/ T13 EIS Interface Support	
2. BSC Submittal No.:	Revision:	Title:
V0-HX00-NHC4-00239-00139-001	003	RA EIS Corridor Analysis for Engineering Input for Part 1 Technical Memo 04/11/07

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Section I. Submittal Information (includes above information)

Submittal Description and Revision Summary for Entire Submittal:

This technical memo provides engineering information for Part 1 of the Rail Alignment Environmental Impact Statement (RA EIS). Section 1 and part of Section 2 present engineering background information. Section 2.3 addresses the specific data requested by U.S. Department of Energy (DOE) for Part 1. Those data can be found in Section 2.3 or the associated appendices. This is a final document.

Special Instructions:

Section II. Data File Information (Add lines below if needed for additional files. Indicate "Last item" or "End of list" after last line used.)

Filename	Rev.	File Size	Description (File description and revision summary for file)	Application and Version/ Add-in or Extension and Version
T13_CorridorAnalysisforEngineeringInput_Rev01_11April2007.pdf	01	4,307 KB	RA EIS Corridor Analysis for Engineering Input for Part 1 Technical Memo pdf of Microsoft Word document	Adobe Acrobat 7.0
T13_Cover_11April07.ppt	01	701 KB	Cover of Report	Microsoft PowerPoint
T13_CorridorAnalysisforEngineeringInput_Rev01_11April2007.doc	01	2,202 KB	Microsoft Word document of Report	Microsoft Word

Section III. Metadata

☒ **GIS Metadata** All GIS data is preferred in ArcGIS9.1 UTM, NAD1983, Zone11, Feet.	Projection:
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	Zone:
	Units:
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STR/STR Support Name: Gene Allen		Signature: EC Allen 4/16/07	Date: 4/16/07

RA EIS Corridor Analysis for Engineering Input for Part 1 Technical Memo

Task 13: EIS Interface Support

Rev. 01

Document No. NRP-R-SYSW-EI-0005-01

prepared by:

prepared for:

Nevada Rail Line Conceptual Design

Subcontract NN-HC4-00239

April 11, 2007

RA EIS Corridor Analysis for Engineering Input for Part 1 Technical Memo

Task 13: EIS Interface Support

Document No. NRP-R-SYSW-EI-0005-01

Nevada Rail Line Conceptual Design
Subcontract NN-HC4-00239
11 April 2007

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List of Tables, Figures and Acronyms

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Acronyms

3D	three-dimensional
ADT	average daily traffic
ALW	Administrative Land Withdrawal
AREMA	American Railway Engineering and Maintenance-of-Way Association
BLM	Bureau of Land Management
BSC	Bechtel SAIC Company, LLC
CAD	computer-aided design
CRC	Caliente Rail Corridor
CTC	centralized train control
DEIS	Draft Environmental Impact Statement
DOE	U.S. Department of Energy
FEMA	Federal Emergency Management Agency
GIS	geographic information systems
MOW	maintenance-of-way
mph	miles per hour
MRC	Mina Rail Corridor
NAD	North American Datum
NOI	Notice of Intent
NRL	Nevada Rail Line
NRP	Nevada Rail Partners
NTRD	Nevada Transportation Requirements Document
NTTR	Nevada Test and Training Range
RA EIS	Rail Alignment Environmental Impact Statement
Repository	Yucca Mountain Geologic Repository
ROD	Record of Decision
ROW	right-of-way
TIN	triangulated irregular network
UPRR	Union Pacific Railroad
UTM	Universal Transfer Mercator
WSA	Wilderness Study Area

1.1 INTRODUCTION

Based on engineering resource needs for Part 1 of the Rail Alignment Environmental Impact Statement (RA EIS), this technical memo provides the requisite information. Section 1.0 and part of Section 2.0 present engineering background information. Section 2.3 addresses the specific data requested by U.S. Department of Energy (DOE) for Part 1 of the RA EIS. This data can be found in Section 2.3 or the associated appendices.

1.2 ALIGNMENT BOUNDARY CONDITIONS

The purpose of this report is to define criteria and considerations utilized in the selection of feasible geometric alignments for the Nevada Rail Line (NRL) that will support a credible evaluation and impacts assessment. The basis of this effort was defined by guiding parameters (bounding conditions) stemming from previous DOE actions, current Yucca Mountain Project program requirements, and ongoing conceptual design activities. These bounding conditions include:

- Engineered alignments prepared in 1997 as support to the Yucca Mountain Geologic Repository (Repository) EIS
- Geographic limits of the Caliente Rail Corridor (CRC) as described in the Repository EIS and the Administrative Land Withdrawal (ALW) petition to the Bureau of Land Management (BLM)
- General routing defined by DOE's RA EIS scoping process and subsequent alternatives-screening
- *Nevada Transportation Requirements Document* (NTRD) (Bechtel SAIC, LLC [BSC]2005)
- NRL Design Criteria (currently in draft status)
- Engineering data needs requested by DOE RA EIS Team

<u>1997 Engineered Alignments</u>: The route segments identified as the CRC in the Repository EIS were developed into engineered alignments (the "MK Alignment"). This alignment was engineered based on criteria and requirements that considered and incorporated certain Class 1 freight railroad standards. The MK Alignment had been developed to meet the following objectives:

- Minimize impacts to stakeholders
- Minimize impacts to areas of environmental concern
- Minimize and balance earthwork (cuts and fills) to yield a cost effective alignment
- Limit train transit time between the town of Caliente and the Repository to allow transit by a single train crew in a 12-hour shift

The objectives of the 1997 rail engineering work were to identify potential rail corridors from various points on the existing rail system in Nevada to the Repository, and to formulate a possible alignment within these corridors. The analyses were performed on a broad level; hence, actual alignment details were based on very general criteria and purposely lacked specific details. A total of five different corridors were developed, as described in the Repository EIS (DOE 2002a).

The engineering data and geometric information from that previous activity were incorporated into the early actions of NRL conceptual design. However, three specific issues prevented continued use of this previously developed alignment as conceptual design progressed:

- The MK Alignment was defined by geometry inconsistent with the current requirements and design criteria established for the NRL (Table 1-1).
- The RA EIS scoping process identified several route segments that were significantly modified from the MK Alignment and identified other segments that were not components of the MK Alignment (DOE 2007).

- The background mapping for the MK Alignment contained topographic discrepancies and did not represent a credible basis for continued development.

The following table lists the criteria that have the greatest impact on alignment selection. From the table it should be apparent that the current concept for the RA EIS provides a more robust design.

Table 1-1. Comparison Table of Engineering Criteria Used in Early Stages of Project Formulation to Current Criteria Proposed by NRL

Parameter	Criteria Used for Repository EIS	Criteria Used for RA EIS
Horizontal curvature (maximum)	8.73 degrees	6.00 degrees
Grades (maximum)	2.0 percent uncompensated for curvature	2.0 percent compensated for curvature
Speed (miles per hour [mph])	60	60
Track section	115-lb. rail timber ties 6–12 inches of ballast light density rail traffic 30 foot top of cross section	136-lb. rail concrete ties 12 inches of ballast 18 inch ballast shoulder 31 foot top of cross section
Service Road	MK service road was assumed to be in flat bottom ditches	A service road parallel to the track for the complete alignment
Wells	One well every five miles	Well locations per specific demand quantities including well locations outside the right-of-way (ROW)
Facilities	Facilities were not in scope for effort	Support facilities for rail operations included: interchange facility, staging yard, end-of-line facility, and maintenance-of-way (MOW) facilities
Signals	No signal-controlled train operations	Centralized train control (CTC) signal system for train operations

CRC and the ALW: The Repository EIS described five corridors for rail-line locations. These rail lines would connect with the national rail system and thus provide an avenue for transporting spent nuclear fuel and high-level radioactive waste from commercial reactors and defense facilities. Of the five corridors described in the Repository EIS, the DOE's Record of Decision (ROD) (Federal Register Vol. 68, No. 248, 29 December 2003) stated that the CRC was the preferred alternative. In the ROD, the CRC was defined as "a strip of land, approximately 0.25 mile (400 meters) wide that encompasses one of several possible routes through which DOE could build a rail line."

Over 99 percent of the CRC lies on public lands administered by the BLM. Concurrently with the publication of the ROD, the BLM filed notice in the Federal Register that the DOE had petitioned to withdraw land from surface entry and mining for a period of 20 years to evaluate the land for the potential construction, operation, and maintenance of a rail line. The width of the land withdrawal is 1.0 mile, and contains the CRC as defined in the Repository EIS.

These two definitions of geographic location, the CRC and the BLM ALW, form the horizontal boundaries for conceptually designing the segments. However, these boundaries were not considered absolute; when feasibility directed the alignment otherwise, the alignments shifted outside the limits of the CRC and the ALW. A third geographic consideration, private property, will be investigated as design continues.

Input from Scoping and Screening: Following the publication of the ROD and the Notice of Intent (NOI), the DOE held a series of scoping meetings in Las Vegas, Armargosa Valley, Goldfield, and Reno, Caliente. The DOE also solicited written comments from the public regarding the intent to prepare the RA EIS for the CRC. This scoping process resulted in the identification of numerous, alternative route segments that included segments of the MK Alignment, modified versions of the MK Alignment, and entirely new segments. These numerous segments were subjected to a screening process and certain segments were eliminated from further consideration. The segments that remained were designated for detailed analysis and evaluation, and this set of segments defined the activities of conceptual design.

NTRD (BSC 2005): The purpose of the NRL is to provide a means of transporting spent nuclear fuel and high-level radioactive waste to the Repository. A secondary purpose of the NRL is to provide construction materials to the Repository and to support Repository operations. DOE has identified specific functional requirements and criteria for design and operation of the NRL. These concepts establish the weight limits for structural loading of the track and bridges, as well as the overall train consists required for determining horsepower, and braking requirements. These program requirements were taken in part from the DOE's *Integrated Interface Control Document, Volume 1* (DOE 2002b). These considerations are important to the formulation of specific criteria for design and operation of the NRL.

Early conceptual design activities considered several topics important to the development of the rail line. These topics included train consists, fencing, access roads, and grades. Of these topics, grades are of critical importance to alignment development and form one of the boundary conditions in the conceptual design process.

NRL Design Criteria: Design criteria have been prepared defining the technical design basis that must be achieved by the conceptual design. These criteria are based on requirements found in the NTRD, which defines the safety and functional requirements associated with waste transport.

These criteria have been developed in coordination with established practices of the national rail system and railroad companies, with industry guidelines such as those published by the American Railway Engineering and Maintenance of Way Association (AREMA), and with other professional associations of the railroad industry. For example, a primary requirement of the NRL calls for a desired design speed of 60 mph. This requirement established limits of horizontal geometry and vertical grade for safe operation. A summary of these criteria is in Appendix A.

Information Requested by EIS Team: The primary objective of conceptual design is to provide engineering design data necessary to support the RA EIS. The DOE's RA EIS contractor provided a list of information needed to complete the engineering sections of the draft environmental impact statement (DEIS).

Environmental considerations were a priority while developing the alignment. The collection of environmental field data (such as biological resources and cultural/historic features) is on-going and concurrent with the conceptual design alignment development. It is anticipated that additional field data inputs will occur, and that the alignment development, as currently documented, may require modification.

1.3 DATA SOURCES

Mapping Data: The basis for conceptual design for the CRC was public domain mapping data from the USGS. Nevada Rail Partners (NRP) acquired software from TopoDepot that provides a computer interface to generate electronic quadrangle maps that can be utilized in Microstation computer-aided design (CAD) software. The USGS maps were compiled from two sets of data: Year 2003 roads, streams, and other landmarks, and Year 2000 (or newer) contour data.

Prior to mapping data for the rail corridor, metric measurements were being utilized as the coordinate system. NRP compiled quadrangle map contours and overlaid them on hill shades provided by BSC, and determined the proposed USGS mapping could be overlaid on BSC geographic information systems (GIS) drawings without requiring coordinate manipulation.

NRP created electronic quadrangle maps for the corridor in Universal Transfer Mercator (UTM) Zone 11, North American Datum (NAD) 27, English. BSC then provided alignments (in English units) derived using Quantm© (further discussed in Section 2.2) which were overlaid, without manipulation, on the electronic quadrangle maps. In order to allow multiple staff users to work simultaneously on the alignment engineering, individual quadrangle maps were used. This individual map use creates a "seam" between maps. This seam can be removed by tiling all the quadrangle maps; however, this method was not used due to the large electronic file size and inability for multiple users to work with the tiled map.

Average daily traffic (ADT) data for state and federal highways were obtained from the Nevada Department of Transportation.

BSC provided mapping data based on 1:20,000-scale aerial photography taken during the spring and summer of 2005. Digital, orthorectified photos, digital terrain models, and topographic maps were generated (in UTM Zone 11, NAD 83, English) as products for use. The change from NAD 27 to NAD 83 was made to comply with project requirements. A large number of planimetric features were captured in the topographic maps (including roads and water features). Other features, such as private lands and jurisdiction, were captured from BSC's GIS database. The digital terrain models were used to generate triangulated irregular network (TIN) models for use in InRoads (discussed in greater detail in Section 2.2) and Quantm©. The TIN models were used to refine the alignment using the Quantm© route optimization program and further refined by engineers using InRoads.

The process for the alignment selection used as the basis for analysis for the CRC is discussed in the following section.

2.0 Alignment Development Process

2.1 PROCESS STEPS

The alignment development process followed a systematic series of steps which first created, and then progressively refined, feasible, engineered alignments. The starting point of this conceptual design development process was the individual route segments that emerged from the RA EIS scoping process for detailed evaluation and analysis. The series of steps that developed the feasible, engineered alignments include:

- Route optimization
- Initial engineered geometry
- Refined and adjusted geometry
- Initial alignment drawings to support field investigations
- Define basis for analysis
- Draft DEIS drawings

These progressive steps developed the alternative route segments that emerged from scoping, into alignments with engineered geometry for analysis and comparative evaluation. The following paragraphs summarize each of these alignment development steps.

2.2 EXPLANATION OF PROCESS FOR THE CRC

<u>Route Optimization</u>: As the RA EIS scoping process identified route segments that would be further developed by conceptual design, those routes were subjected to an alignment optimization process. This optimization was conducted with the use of a specialized analysis tool called Quantm©. Quantm© analyzes a linear route in three dimensions to establish, analyze, and compare a large number (thousands) of alternative three-dimensional (3D) lines through the designated background mapping space. This optimization was an iterative process that repeatedly responded to evolving segment identification over a period of months during the RA EIS scoping timeframe and early conceptual design. This optimization also refined the routing of many potential segments, including three specific segment categories.

- Segments of the MK Alignment were optimized with the constraint of remaining within the 0.25-mile-wide CRC. The optimization process was based on the performance criteria listed in the NTRD, and the design criteria in Appendix A. The optimization process incorporated qualitative cost factors that allowed Quantm© to compare certain design options (e.g., a tunnel versus a deep cut) during the course of its optimization analysis, and also considered environmental (e.g., natural and human) resources.
- The same MK Alignment segments (described in the preceding bullet) were optimized within the 1.0-mile-wide ALW, and were optimized again without any corridor constraint. Additional optimization and corresponding earthwork reduction was achieved.
- As the RA EIS scoping process identified route segments that were either considerable modifications from the MK Alignment or entirely new segments, the optimization process described in the previous two bullets were conducted on these segments.

The Quantm©-based optimization steps defined planning-level alignments that represented a starting point for alignment engineering. The Quantm© system:

- Incorporates technical parameters (into the Quantm© modeling software) directly generated by the early conceptual design process
- Provides detailed (3D) information early in the process on segment alignments driven by conceptual design criteria and basis-of-design engineering parameters

- Reviews thousands of alignment variations driven by technical, community, political, or legal requirements
- Considers "what if" scenarios and conducts sensitivity testing either in isolation or in combination for segment(s) based on:
  - Cost of construction
  - Socioeconomics
  - Rail geometry
  - Land impacts
- Considers macro-level environmental features such as:
  - Wilderness areas
  - Wilderness Study Areas (WSAs)
  - Nevada Test and Training Range (NTTR)
  - Patented mining claims
  - Private lands

Initial Engineered Geometry: Output from the Quantm© model was finalized for all segments that were identified in the RA EIS screening process as segments suitable for further analysis. These Quantm© alignments were transferred as electronic files from the planning/optimization work team to the alignment engineering work team in order to create the initial, engineered alignment geometry. In this step, the 3D Quantm© lines through space were first converted (as "traced alignments") into a CAD platform. This CAD platform is Intergraph Microstation (Version 8) along with the alignment-specialty software InRoads (Version 8). Microstation is a civil engineering software package used for creating engineering drawings. InRoads is a software package that computes an alignment's horizontal and vertical geometry and also computes the cut and fill (earthwork) needed to construct the defined alignment. InRoads computes an alignment's geometry incorporating topographic information, a designated location, cross section templates, and engineering criteria. The completion of this step resulted in an alignment that was generally similar (and in places, nearly identical) to the optimized Quantm© output, but defined by specific geometric parameters such as horizontal curve geometry, tangent segment lengths, and vertical grade percentages.

Refined and Adjusted Geometry: Plots of each initially-engineered InRoads alignment were examined for opportunities to refine the alignments. The effect of these refinements:

- Established alignment geometry that adhered to the NRL requirements and design criteria. The refinement reduced the potential areas of speed restrictions and thus improved transit time across the alignment segments.
- Improved operational safety, reliability and functionality. The rail alignment was refined
  - to remove geometric conditions such as reverse curves without intermediate tangent segments
  - to reduce track with horizontal curves superimposed on vertical curves
  - to compensate vertical grade where horizontal curves occurred
  - to reduce vertical undulation and the associated roller coaster effect
- Achieved improved constructability. In a few alignments, embankment fills areas were very high, that is over 100 feet above the natural grade. Rather than engineer a bridge at these locations, the conceptual design was adjusted to include embankment fill. This would provide the RA EIS process with a design that would represent a bounding case for surface area disturbance, earth moved, and other environmental factors.

- Lowered operational cost. Because frequent curvature, tunnels, and frequent changes in vertical gradient are all features that increase operating costs, the refinements focused on areas where curves and gradients could be flattened, and where tunnels could be avoided.
- Reduced complex geometry. Tangent sections were inserted in some portions of the alignment to reduce the frequency of reverse curves.
- Made more efficient use of existing terrain. The alignment was moved within the CRC to take advantage of slopes and hillsides that would smooth the profile by refining vertical curves. In other segments, the alignment was adjusted to improve the earthwork balance, which improves constructability. Balanced earthwork also reduces permitting issues by eliminating the need to permit borrow sources or waste spoil areas.

Other refinements including adjusting the alignment to shorten bridges, or shifting the alignment to avoid costly engineering works such as tunnels. The consideration of these engineering issues resulted in repeated, iterative refinements of the initial InRoads alignment until it was judged that a feasible alignment (given the current, available data) was developed.

<u>Initial Alignment Drawing to Support Field Investigations</u>: Once a refined and adjusted alignment was identified, plan and profile information were plotted and distributed to the RA EIS team as interim documents. The plots were at a horizontal scale of 1 inch = 2,000 feet. Electronic versions were also provided so that the RA EIS team could reproduce the information at a different scale, depending upon the desired use. These drawings were used by the RA EIS team to guide field investigations and to locate environmental resources such as wetlands, unique habitat, or cultural features.

The current status of the conceptual design presents an alignment that successfully executes the DOE's ROD for the Repository and NOI for the RA EIS. The alignment development process followed these steps:

- Acknowledge any environmental avoidance areas designated by the RA EIS contractor
- Seek a feasible engineering alignment within the CRC
- Evaluate if impacts (such as total earth moved) can be reduced with an alignment beyond the corridor and within current ALW limits
- Evaluate any remaining high-impact areas within alignments outside the ALW

Following receipt of new aerial mapping and terrain models, Quantm© was again used to evaluate the alignment in light of the new topographic data. Output from the Quantm© model was then transferred electronically to InRoads to help guide further geometric refinements. The alignment typically altered the centerline location by several hundred feet, and occasionally a greater distance, if impacts could be reduced and alignment's feasibility could be improved.

Environmental considerations were a priority while developing the alignment. Water availability is a major issue that simultaneously affects the NRL's engineering design, environmental effects, permitting constraints, and project costs. The principal factor affecting water demand is earthwork–about 90 percent of the water needed for the project would be used to provide for compaction of embankment fill materials, and to control dust during excavation and other earth-moving activities. The track profile was prepared with the objective of trying to balance earthwork quantities; that is, keeping the total excavation (cut) approximately equal to the placement of embankment (fill). However, the conceptual design approach was to adjust the profile so that cut and fill would be reduced. By reducing fill, the water demand for embankment compaction is also reduced.

The alignment was prepared with limited hydrologic and hydraulic data input. Preliminary design discharges for drainage structures along the alignment were determined using data from regionalized regression equations. For structures that would be located in Federal Emergency Management Agency (FEMA) Flood Zone A, the 100-year floodplain, they would be designed to convey 100-year flows with minimal impoundment of water upstream of the structure consistent with FEMA guidelines and county regulations. When the structures are located in areas not studied by FEMA, they would be designed to comply with appropriate county regulations. The design would temporarily impound flows but would minimize potential impacts to flooding and sediment transport at other locations.

Additional environmental factors were also considered in deriving the alignment. This information included the identification of known areas of potential cultural resources impacts. During the process, areas of potential cultural issues were identified; many of these are reflected in the American Indian Resource Document prepared by the American Indian Writers Subgroup in June 2005. The alignment was subsequently adjusted to decrease or eliminate the impacts in these areas.

There are differences in the engineering stations of the current alignments when compared to those of the original segments. The differences appear as shifts in the original station locations, station overlaps at the ends of and sometimes within segments, and station gaps. These differences are due to the fragmented nature of the alignments when compared to the submittal schedule, and to the fact that most segments now are longer due to the objective of reducing earthwork quantities.

Basis for Analysis: The final step in the alignment development process was to compare the alternative segments for the purpose of identifying a continuous alignment that could be used as the basis for analysis alignment for other components of the conceptual design. These components include:

- *Air Quality Emission Factors and Socioeconomic Input, Caliente Rail Corridor* (NRP 2007a)
- *Comparative Cost Estimates, Caliente Rail Corridor* (NRP 2007e)
- *Construction Plan, Caliente Rail Corridor* (NRP 2007f)
- *Operations and Maintenance Report, Caliente Rail Corridor* (NRP 2007g)

2.3 MINA RAIL CORRIDOR

The Mina Rail Corridor (MRC) was similarly analyzed, although alignments were selected without the use of Quantm©. Note: No MK or "MK Factored" data (see discussion below in Section 2.4) was developed for this corridor.

2.4 OTHER ALIGNMENTS

2.4.1 Data Correlations

For the remaining corridors (Carlin, Jean, and Valley Modified), numerical ratios of primary impact indicators (e.g., length of route and earthwork quantities) were used to correlate the MK data to the current criteria analysis. Ratios used were developed by dividing the NRP CRC value by the MK Alignment value for the corresponding impact driver. This ratio was then applied to the other MK values in order to develop an "MK Factored" value. Values for water demand were similarly calculated with respect to the values developed for the NRP CRC. Material requirement estimates were then developed based on the length of line for steel (main track rail) and concrete (main track ties) usage. A percentage of these results was added to account for other uses of those materials. The results of this process for the Jean, Valley Modified, and Carlin corridors are tabulated in Table 2-1. Similarly, the hydrologic basins for each corridor are listed in Table 2-2. Land disturbance impacts that result in average width of 325 feet for the CRC are presented in Table 2-3. Application of this average land disturbance width to the other corridors is presented in Table 2-4.

2.4.2 Summary of Data Requests and Data Locations

Hydrology (Water Appropriations and Water Usage): The hydrologic basins for each corridor are identified in Table 2-2 with a percentage of the corridor within each basin based upon MK analysis.

Total water demand for each corridor is shown in Table 2-1. The water demand within each hydrologic basin may be calculated by multiplying the corridor demand total in Table 2-1 by the respective percentage in Table 2-2 (see Table 2-2, note 3).

Terrain types were not needed to develop the total water demand since MK and NRP used similar methods for defining earthwork needs by excavation type (e.g., common, rippable rock, drill and blast, and borrow). The terrain types and distances for each of the four corridors is addressed in the escalation analysis for earthworks and water demand (see Table 2-1). The *Nevada Transportation Study Construction Cost Estimate* (Morrison Knudsen Corporation 1998) provided cost data for each of the corridors addressed in the Repository EIS (DOE 2002a): Carlin, Caliente, Valley Modified and Jean. These categories included common (alluvial material), rippable rock, and drill and blast (solid bedrock). The earthwork component of the cost estimate adequately characterizes the complexity of the terrains crossed by each of the corridors. Because these data were used in assessing the escalation factors, the subsequent earthwork calculations effectively address the significant contributory component of the terrain factor.

Land Disturbance: Land disturbance for each corridor (approximately 1,300 feet wide) is presented in Table 2-4. Land disturbance computations from *Air Quality Emission Factors and Socioeconomic Input, Caliente Rail Corridor* (NRP 2007a) were used to calculate an average width of the CRC alignment as shown in Table 2-3. That width of 322 feet was rounded to 325 feet and used to estimate land disturbance for the other corridors as shown in Table 2-4.

Land disturbance for ancillary facilities and quarries is shown in Table 2-3.

Utilities, Energy, and Materials: Total concrete and steel, which are proportional to a ratio of corridor lengths, for each corridor are presented in Table 2-1. Diesel fuel use, which is proportional to the quantity of earthwork needed, is also presented Table 2-1. Gasoline fuel is expected to be less than the diesel fuel total gallons and is also proportional to the earthwork quantities. However, gasoline use for the CRC has not been calculated.

Ancillary Facilities and Quarries: Ancillary facilities are expected to be essentially the same for all corridors (e.g., Union Pacific Railroad [UPRR] interchange, staging yard, MOW facilities, and an end-of-line facility). The CRC reference documents provide the available information about those facilities.

For the Mina and Carlin corridors, two quarries would be expected, one near the start of the line and one midway. For the Jean and Valley Modified corridors, one quarry would be expected due to shorter routes.

2.4.3 Air Quality

Background: The air quality emissions for construction and operation of the CRC are documented in the *Air Quality Emission Factors and Socioeconomic Input, Caliente Rail Corridor* (NRP 2007a). Earthwork and associated vehicle traffic form the basis of the construction emissions estimate and hours of operation form the basis for the operational emission estimate. Similar air quality emission factors are not available for the Carlin, Valley Modified or Jean corridors. Air quality emission factors for the MRC are contained in *Air Quality Emission Factors and Socioeconomic Input, Mina Rail Corridor* (NRP 2007b).

Air quality analysis was performed by Jason Associates (see Repository EIS and associated Transportation Air Quality calculations package MOL. 20020131.0054) for the Valley Modified corridor. Those analyses focused on carbon monoxide for operations and fugitive dust for construction. Operations were modeled as a function of train traffic. Construction fugitive dust was considered to be proportional to earthwork (stated in calculations package MOL. 20020131.0054), but was not modeled based upon earth moving and vehicle traffic since those data were not available. Instead, an aerial model for construction of apartments and shopping centers (basic parameters are area disturbed times duration of disturbance) was used.

The amount of earthwork for the CRC has been estimated by NRP in *Alignment Development Report, Caliente Rail Corridor* (NRP 2007c). The amount of earthwork for the Valley Modified, Jean, and Carlin corridors has been estimated by MK (see Repository EIS and associated MK references). Earthwork for the currently proposed MRC is estimated in *Mina Rail Route Feasibility Study* (BSC 2006) and has also been submitted to BSC as part of *Alignment Development Report, Mina Rail Corridor* (NRP 2007d).

2.4.4 Factors for Relating CRC Emissions to other Corridors

Construction air quality emissions are proportional to the amount of earthwork required to build the railroad. Earthwork is defined as the amount of earth movement that will take place. Amount of earthwork is also proportional to the amount of vehicle emissions (i.e., less earthwork needed then less time of vehicle operation and, therefore, less vehicle emissions). Based upon this, it is recommended that the Part 1 air quality analysis use the ratio of earthwork for the corridor to be updated to the earthwork for CRC to proportion the CRC air quality emissions. (See elsewhere in this report for earthwork comparative data.)

For some population centers where a staging yard or MOW maybe located, use the emission factors that have been developed for the CRC staging yards and MOW (see draft RA EIS air quality analysis).

For operational emissions, use the emission factors that have been developed for the CRC and apply them to the linear corridor appropriately.

<u>GIS Mapping and Figures</u>: One map of the five corridors and three maps showing MRC scoping alignments, potential changes due to scoping, and changes from scoping are presented in Appendix B. GIS mapping information for corridors is not part of this report. BSC is providing that information separately.

Table 2-1. Corridor Adjustment Factors

CALIENTE (process check)					Diesel Fuel:
		MK Orginal	Ratio	MK Factored	34,000,000 gals
Length	miles	322.2 miles	1.03	330.6 miles	
Excavation - Common	cubic yard	11,140,000 cy	1.98	22,094,000 cy	Water Demand:
Excavation - Rippable Rock	cubic yard	8,071,000 cy	0.26	2,074,000 cy	6100 ac. ft.
Excavation - Drill and Blast	cubic yard	5,978,000 cy	1.14	6,800,000 cy	
Excavation - Borrow (Common)	cubic yard	12,655,000 cy	0.50	6,311,000 cy	Steel:
Place Embankment	cubic yard	21,810,000 cy	1.15	25,135,000 cy	94,959 tons
Total Earthwork	cubic yard	59,654,000 cy	1.05	62,414,000 cy	Concrete:
					366,569 tons
Total Estimated Cost (less facilities)		$723,323,500	2.85	$2,061,380,000	
Facilities Estimate				$131,086,000	
Total Estimated Cost				$2,192,466,000	
JEAN					Diesel Fuel:
		MK Original	Ratio	MK Factored	22,561,000 gals
Length	miles	112.1 miles	1.03	115.0 miles	
Excavation - Common	cubic yard	7,020,000 cy	1.98	13,923,000 cy	Water Demand:
Excavation - Rippable Rock	cubic yard	7,181,000 cy	0.26	1,845,000 cy	3383 ac. ft.
Excavation - Drill and Blast	cubic yard	5,319,000 cy	1.14	6,050,000 cy	
Excavation - Borrow (Common)	cubic yard	7,970,000 cy	0.50	3,975,000 cy	Steel:
Place Embankment	cubic yard	12,095,000 cy	1.15	13,939,000 cy	33,038 tons
Total Earthwork	cubic yard	39,585,000 cy	1.05	41,416,000 cy	Concrete:
					127,536 tons
Total Estimated Cost (less facilities)		$374,011,000	2.85	$1,065,883,792	
Facilities Estimate				$131,086,000	
Total Estimated Cost				$1,196,969,792	
VALLEY MODIFIED					Diesel Fuel:
		MK Original	Ratio	MK Factored	12,906,000 gals
Length	miles	98.4 miles	1.03	101.0 miles	
Excavation - Common	cubic yard	1,319,000 cy	1.98	2,616,000 cy	Water Demand:
Excavation - Rippable Rock	cubic yard	1,486,000 cy	0.26	382,000 cy	2792 ac. ft.
Excavation - Drill and Blast	cubic yard	1,101,000 cy	1.14	1,252,000 cy	
Excavation - Borrow (Common)	cubic yard	9,061,000 cy	0.50	4,519,000 cy	Steel:
Place Embankment	cubic yard	9,677,000 cy	1.15	11,152,000 cy	29,011 tons
Total Earthwork	cubic yard	22,644,000 cy	1.05	23,692,000 cy	Concrete:
					111,992 tons
Total Estimated Cost (less facilities)		$213,348,800	2.85	$608,016,951	
Facilities Estimate				$131,086,000	
Total Estimated Cost				$739,102,951	
CARLIN					Diesel Fuel:
		MK Original	Ratio	MK Factored	30,342,000 gals
Length	miles	322.9 miles	1.03	331.4 miles	
Excavation - Common	cubic yard	7,259,000 cy	1.98	14,397,000 cy	Water Demand:
Excavation - Rippable Rock	cubic yard	6,888,000 cy	0.26	1,770,000 cy	5780 ac. ft.
Excavation - Drill and Blast	cubic yard	5,102,000 cy	1.14	5,804,000 cy	
Excavation - Borrow (Common)	cubic yard	13,560,000 cy	0.50	6,762,000 cy	Steel:
Place Embankment	cubic yard	20,427,000 cy	1.15	23,541,000 cy	95,179 tons
Total Earthwork	cubic yard	53,236,000 cy	1.05	55,699,000 cy	Concrete:
					367,417 tons
Total Estimated Cost (less facilities)		$678,540,200	2.85	$1,933,753,289	
Facilities Estimate				$131,086,000	
Total Estimated Cost				$2,064,839,289	
MINA					Diesel Fuel:
		MK Original	Ratio	NRP April 2007	33,194,000 gals
Length	miles	n/a	n/a	254.4 miles	
Excavation - Common	cubic yard	n/a	n/a	8,975,000 cy	Water Demand:
Excavation - Rippable Rock	cubic yard	n/a	n/a	5,496,000 cy	5950 ac. ft.
Excavation - Drill and Blast	cubic yard	n/a	n/a	3,005,000 cy	
Excavation - Borrow (Common)	cubic yard	n/a	n/a	17,817,000 cy	Steel:
Place Embankment	cubic yard	n/a	n/a	25,642,000 cy	73,072 tons
Total Earthwork	cubic yard	n/a	n/a	60,935,000 cy	Concrete:
					282,079 tons

Table 2-2. Hydrologic Basins

Rail Corridor	Hydrologic Basin (subbasin where applicable)	Length (miles)	Percentage of Corridor Total (3)	Designated (Total % of distance in Designated Groundwater Basins(4))
Caliente (process check)(1)	Clover Valley	3.81	1.18	no
	Coal Valley	16.18	5.02	no
	Crater Flat	18.23	5.65	no
	Dry Lake Valley	24.99	7.75	no
	Fortymile Canyon/Jackass Flats	7.83	2.43	no
	Garden Valley	16.34	5.07	no
	Hot Creek	21.3	6.60	no
	Lida Valley	14.66	4.54	no
	Oasis Valley	14.41	4.47	yes
	Pahroc Valley	19.21	5.95	no
	Panaca Valley	18.32	5.68	yes
	Penoyer Valley	18.41	5.71	yes
	Railroad Valley/Southern Part	26.15	8.11	no
	Ralston Valley	28.01	8.68	yes
	Sarcobatus Flat	29.53	9.15	yes
	Stone Cabin Valley	32.43	10.05	yes
	Stonewall Flat	12.78	3.96	no
Caliente Total		322.59	100.00	43.74
Carlin(1)	Alkali Spring Valley	13.26	4.02	no
	Big Smoky Valley/Northern Part	68.21	20.70	yes
	Big Smoky Valley/Tonopah Flat	47.06	14.28	yes
	Carico Lake Valley	2.71	0.82	no
	Crater Flat	18.23	5.53	no
	Crescent Valley	49.54	15.04	yes
	Fortymile Canyon/Jackass Flats	7.83	2.38	no
	Grass Valley	34.34	10.42	no
	Lida Valley	14.66	4.45	no
	Oasis Valley	14.41	4.37	yes
	Ralston Valley	16.93	5.14	yes
	Sarcobatus Flat	29.53	8.96	yes
	Stonewall Flat	12.78	3.88	no
Carlin Total		329.49	100.00	68.49
Jean(1)	Amargosa Desert	26.11	23.28	yes
	Fortymile Canyon/Jackass Flats	12.97	11.56	no
	Ivanpah Valley/Southern Part	19.02	16.96	yes
	Mesquite Valley	12.48	11.13	yes
	Pahrump Valley	39.53	35.24	yes
	Rock Valley	2.06	1.84	no
Jean Total		112.17	100.00	86.60
Valley(1)	Fortymile Canyon/Jackass Flats	10.78	10.94	no
	Indian Springs Valley	18.04	18.31	yes
	Las Vegas Valley	35.03	35.55	yes
	Mercury Valley	11.69	11.86	no
	Rock Valley	11.42	11.59	no
	Three Lakes Valley	11.58	11.75	no
Valley Total		98.54	100.00	53.86
Mina(2)	Alkali Spring Valley	4.72	1.85	no
	Big Smoky Valley/Tonopah Flat	14.90	5.84	yes
	Clayton Valley	32.70	12.82	no
	Columbus Salt Marsh Valley	18.46	7.24	no
	Crater Flat	17.90	7.02	no
	Fortymile Canyon/Jackass Flats	8.60	3.37	no
	Lida Valley	31.59	12.39	no
	Oasis Valley	14.50	5.69	yes
	Rhodes Salt Marsh Valley	10.81	4.24	no
	Sarcobatus Flat	29.75	11.67	yes
	Soda Spring Valley/Eastern Part	18.28	7.17	yes
	Soda Spring Valley/Western Part	11.44	4.48	yes
	Walker Lake Valley/Schurz Subarea	31.85	12.49	no
	Walker Lake Valley/Whiskey Flat-Hawthorne Subarea	9.54	3.74	yes
Mina Total		255.02	100.00	38.58

Note: 1) Based on Primary alternatives in Repository EIS
2) Mina basis for analysis consists of S1, MCS1, MN1, MCS2, BC3, CS5, OV1, CS6
3) To calculate water demand for each basin, multiply the total water demand for a given corridor by the percentage
4) Designated Groundwater Basin - A basin where permitted ground water rights approach or exceed the estimated average annual recharge.

Table 2-3. CRC Land Disturbance Summary

Information from NRP Air Quality Emission Factors and Socioeconomic Input, Caliente Rail Corridor, Rev 01 13 April 2006

	Segment	Length Feet	Length Miles	ROW Area (acres)	Disturbed Area (acres) InRoads	Additions 160 ft	Contingency 20%	Total	Calc'd average width (ft)	(total acres X 43560)/length
Basis for Analysis	Caliente	59,188	11.21	1,359	90	220	60	370	272	370 X 43,560/59,188
	Bennett Pass	135,000	25.57	3,099	340	500	170	1,010	326	
	Pahroc Summit	98,276	18.61	2,256	280	360	130	770	341	
	White River	139,099	26.34	3,193	250	510	150	910	285	
	GV8	119,981	22.72	2,754	230	440	130	800	290	
	CS2	161,762	30.64	3,714	280	590	170	1,040	280	
	SR3	65,000	12.31	1,492	110	240	70	420	281	
	CS3	369,313	69.95	8,478	660	1,360	400	2,420	285	
	GF3	164,085	31.08	3,767	360	600	190	1,150	305	
	CS4	37,917	7.18	870	70	140	40	250	287	
	BC3	65,192	12.35	1,497	140	240	80	460	307	
	CS5	131,224	24.85	3,012	160	480	130	770	256	
	OV1	32,421	6.14	744	80	120	40	240	322	
	CS6	167,997	31.82	3,857	480	620	220	1,320	342	
	Totals	1,746,455	330.77	40,092	3,530	6,420	1,980	11,930	298	average for basis
Alternate Alignment Segments	Eccles	58,700	11.12	1,348	190	220	60	470	349	
	GV1	114,685	21.72	2,633	180	420	120	720	273	
	GV2	117,299	22.22	2,693	210	430	130	770	286	292
	GV3	123,405	23.37	2,833	200	450	130	780	275	average for alternates
	SR2	65,000	12.31	1,492	60	240	60	360	241	
	GF1	154,725	29.30	3,552	310	570	180	1,060	298	
	GF4	172,345	32.64	3,956	340	630	190	1,160	293	
	BC2	66,224	12.54	1,520	150	240	80	470	309	
	OV3	46,377	8.78	1,065	100	170	50	320	301	

NOTES:
1) Source: InRoads output, January 2006.
2) InRoads area rounded to nearest 10 acres of value shown on InRoads results.
3) ROW area based on 1,000-foot ROW width.
4) Additions to disturbed area account for alignment access roads on both sides of alignment (160 feet).
5) Contingency adds 20% to sum of InRoads and Additions columns.

Feature	Acres
From page A-6, CRC AQ report	
Camps (12)	730
From page 2-3, CRC AQ report	
Wells (170)	244
From page B-3, CRC AQ report	
Basis area	11,930
Total	**12,904**
Average width with wells camps & basis of analysis alignment	322

Use an average alignment width of **325 feet**

Land Disturbance not in the ROW	
From Page A-5, CRC AQ report	
Interchange Yard	15
NRL Staging Yard*	50
MOW Trackside*	15
MOW Headquarters	0
NRL EOL Yard*	100
From page A-6, CRC AQ report	
Quarries(2)	329
Wells outside ROW	240
Total other	**749**

Table 2-4. Corridor Land Disturbance

Land Disturbance within the 1300' Corridor								
	Length (kilometers)		Length (miles)		Disturbance (acres) inside 1300 ft. Corridor (2)		Disturbance (square kilometers) inside 1300 ft. Corridor	
Carlin	Min	Max	Min	Max	Min	Max	Min	Max
Primary Length		520.0		323.1		12,753		51.61
Range due to Variations	513	544	319	388	12,590	15,314	50.95	61.97
Crescent Valley Alternate		24.5		15.2		600		2.43
Wood Spring Canyon Alternate		11.7		7.3		287		1.16
Rye Patch Alternate		35.3		21.9		866		3.50
Steiner Creek Alternate		41.5		25.8		1,018		4.12
Big Smokey Valley Option		197.0		122.4		4,831		19.55
Monitor Valley Option		225.4		140.1		5,528		22.37
Mud Lake Alternate		(1)		(1)		(1)		(1)
Goldfiled Alternate		43.1		26.8		1,057		4.28
Bonnie Claire Alternate		42.2		26.2		1,035		4.19
Oasis Valley Alternate		5.6		3.5		137		0.55
Beatty Wash Alternate		23.0		14.3		564		2.28
Jean								
Primary Length		181.0		112.5		4,439		17.96
Range due to Variations	181	204	112	127	4,420	5,012	17.89	20.29
Wilson Pass Option		73.5		45.7		1,803		7.29
Pahrump Valley Alternate		32.1		19.9		787		3.19
Stateline Pass Option		91.9		57.1		2,254		9.12
Valley Modified								
Primary Length		159.0		98.8		3,899		15.78
Range due to Variations	157	163	98	101	3,868	3,986	15.65	16.13
Indian Hills Alternate		45.2		28.1		1,108		4.49
Sheep Mountain Alternate		23.3		14.5		571		2.31
Valley Connection		21.1		13.1		517		2.09
Mina								
Primary Length (3)		408.8		254.0		9,153		37.04
Range due to Variations	409	457	254	284	9,153	10,097	37.04	40.86
S4 Alternative Alignment(4)		65.0		40.4		518		2.10
S5 Alternative Alignment(5)		70.8		44.0		644		2.60
S6 Alternative Alignment(6)		71.9		44.7		652		2.64
MN2 Alternative Alignment		118.4		73.6		2,905		11.76
MN3 Alternative Alignment		157.6		97.9		3,864		15.64
BC2 Alternative Alignment		24.9		15.5		612		2.48
OV3 Alternative Alignment		13.2		8.2		324		1.31

Notes

(1) Mud Lake included in other alternates
(2) Assumption is an average disturbance width of 325 ft. within the 1300 ft. Corridor Includes Camps and Wells inside ROW.
(3) Corridor and ROW limited to 100 ft. across Walker River Paiute Lands, inc. 31.9 miles crossing WRP lands
(4) Corridor and ROW limited to 100 ft. across Walker River Paiute Lands, inc. 30.4 miles crossing WRP lands
(5) Corridor and ROW limited to 100 ft. across Walker River Paiute Lands, inc. 40 miles crossing WRP lands
(6) Corridor and ROW limited to 100 ft. across Walker River Paiute Lands, inc. 40.7 miles crossing WRP lands

Conversion Factors Used

km = miles * .621371
acres = sq. ft. * .000023
sq. km. = acres * .004047

3.0 References and Applicable Documents

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Morrison Knudsen Corporation. 1998. *Nevada Transportation Study Construction Cost Estimate.* Boise, ID: Morrison Knudsen. March 1998.

NRP . 2007a. *Air Quality Emission Factors and Socioeconomic Input, Caliente Rail Corridor.* Las Vegas, NV: NRP. NRP-R-SYSW-AQ-0002-03, Rev. 03, 11 May 2007.

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Appendix A
Proposed NRL Design Criteria Basic Elements

PROPOSED NRL (YUCCA MOUNTAIN) Design Criteria Basic Elements

Prepared by NRP – June 15, 2005

A design criteria manual for the proposed rail line to Yucca Mountain is currently being developed. The following table is an extract (summary) from the manual of the basic design elements. These design elements were used in the route selection and optimization analysis for the CRC and MRC.

Table A-1. Summary – NRL Design Criteria

Design Element	Recommend Standard	Comments
Civil Works Design Speed	60 mph (Mainline)	Where practical
Operating Train Speed	Maximum 50 mph (Mainline)	Operating speed governed by curvature and grade
Design Loading	Cooper E-80	Maximum allowable axle load = 34 tons
Track Centers	25 feet sidings and yards	Between track centerlines
ROW	The recommended ROW concept for federal lands is as follows: • Adopt a 1,000-foot wide ROW end-to-end centered on the conceptual design alignment centerline, to be used for the construction phase. Exceptions will be in areas containing: – railyards – wetlands – private property – tribal lands – county roads – state highways – NTTR – Wilderness Area/WSA – U.S. Forest Service jurisdictions • Generally the ROW will allow for the NRL track and structures including earthwork; for construction-phase activities; for siting of wells and communication towers; and for NRL ancillaries such siding and passing tracks. • Additional ROW boundaries will be designated for extraordinary requirements such as construction camps, perpendicular access roads, rail yards and/or facilities, ballast quarries, and other features that will be implemented outside of the nominal, 1,000-foot ROW.	
Alignment Width	• 200 to 1,000 feet nominal • 100 feet (Single Track) minimum • 130 feet (at sidings)	Using retaining walls as required

Table A-1. Summary – NRL Design Criteria

Design Element	Recommend Standard	Comments
Turnouts: • Sidings (Main line) • Yards and Back Tracks	 • No. 20 Power operated • No. 11	 • Eccles may require greater than No. 20 turnouts on UPRR line
Siding Length	• 10,500 feet minimum clear at Caliente and Eccles • 6,000 feet minimum clear elsewhere on the NRL	• Accommodate UPRR trains at Caliente • Siding spacing 20 to 35 miles
Train Control	CTC	
Roadbed Sections: • Roadbed Width (fill) • Roadbed Width (cut) • Subballast Depth • Depth of Ditches	 • 15 feet-6 inches from centerline, 31 feet total • 62 total feet • 6 inches minimum • Typically 3 feet	Reference typical Class 1 - North American Railroad standard, main line with concrete ties
Vertical Curves: • Rate of Change Between Track Gradients (Main Line)	 • Comply with AREMA speed-based criteria	 • Will vary for yards, sidings and back tracks
Vertical Grades: • Maximum (Allowable)	 • 2.0% (curve compensated)	 • Mainline grades on curves must be compensated at 0.04% per degree of curve
Horizontal Curves: • Maximum Degree of Curve • Yards and Sidings • Minimum Length of Spiral per ½ inch of Superelevation	 • 6° - 00" (mainline) Radius = 955 feet • 10° - 00" (Radius = 574 feet) • 30 feet	
Tangent Lengths (between Horizontal Reverse Curves)	• 300 feet (Main Line) • 150 feet (Yards, Sidings and Back Tracks)	
Rail	136-lb RE Minimum	Premium rail (head hardened) on curves 2 degrees and greater
Ties	Prestressed concrete	
Superelevation: • Maximum • Maximum Unbalance Superelevation	 • 4 inches • 1 inch	Based on Class I Railroad standards and maximum operating speed of 50 mph
Clearances for Highway Overpass: • Vertical • Horizontal from Track Centerline to Face of Pier	 • 24 feet minimum • 25 feet minimum	 • Above top-of-rail

Table A-1. Summary – NRL Design Criteria

Design Element	Recommend Standard	Comments
Lateral Clearance – Mainline (to fixed object)	• 10 feet minimum (from centerline) • 9 feet on thru plate bridges	Nevada Public Utilities Commission requires 8 - 9.5 feet on curved track
Ballast	2-¾ inch to 1 inch	18 inch shoulders, 3:1 slopes; 12 inch minimum depth below bottom of tie
Crossings: • State and Federal Highways (Public) • All other Public Roads • Farm and other roads	• Grade Separated • Crossing at Grade • Passive (Cross-bucks)	Automatic Crossing protection (warning system) may be warranted on a case by case basis for crossing at-grade public roads Private crossing license
Clearance Envelope	Association of American Railroads Plate F	
Asset Protection		Fully automated on-line
Communications	Train to Wayside, two-way	Fiber-optic communications cable

Appendix B
Corridor Maps

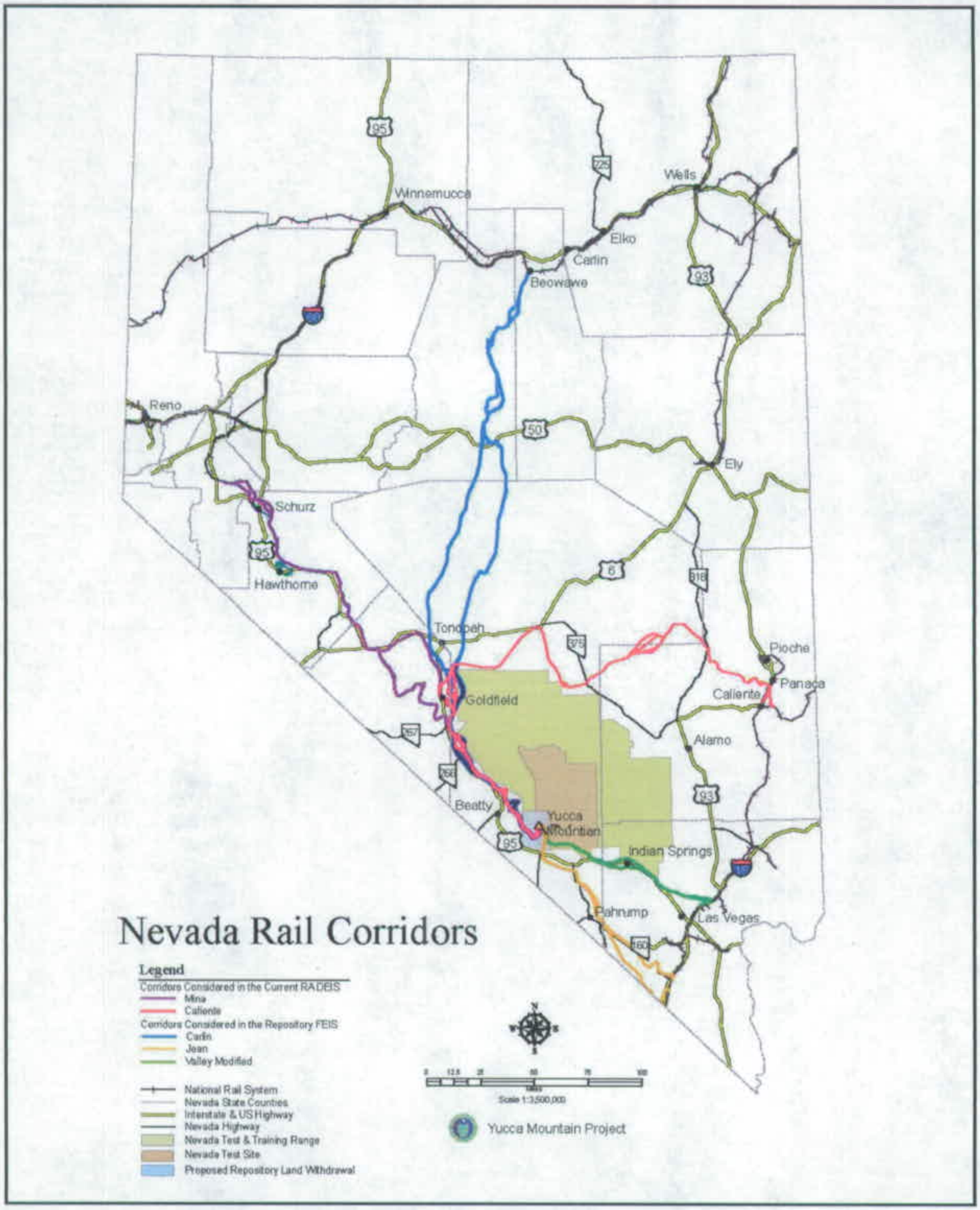

Figure B-1. Nevada Rail Corridors

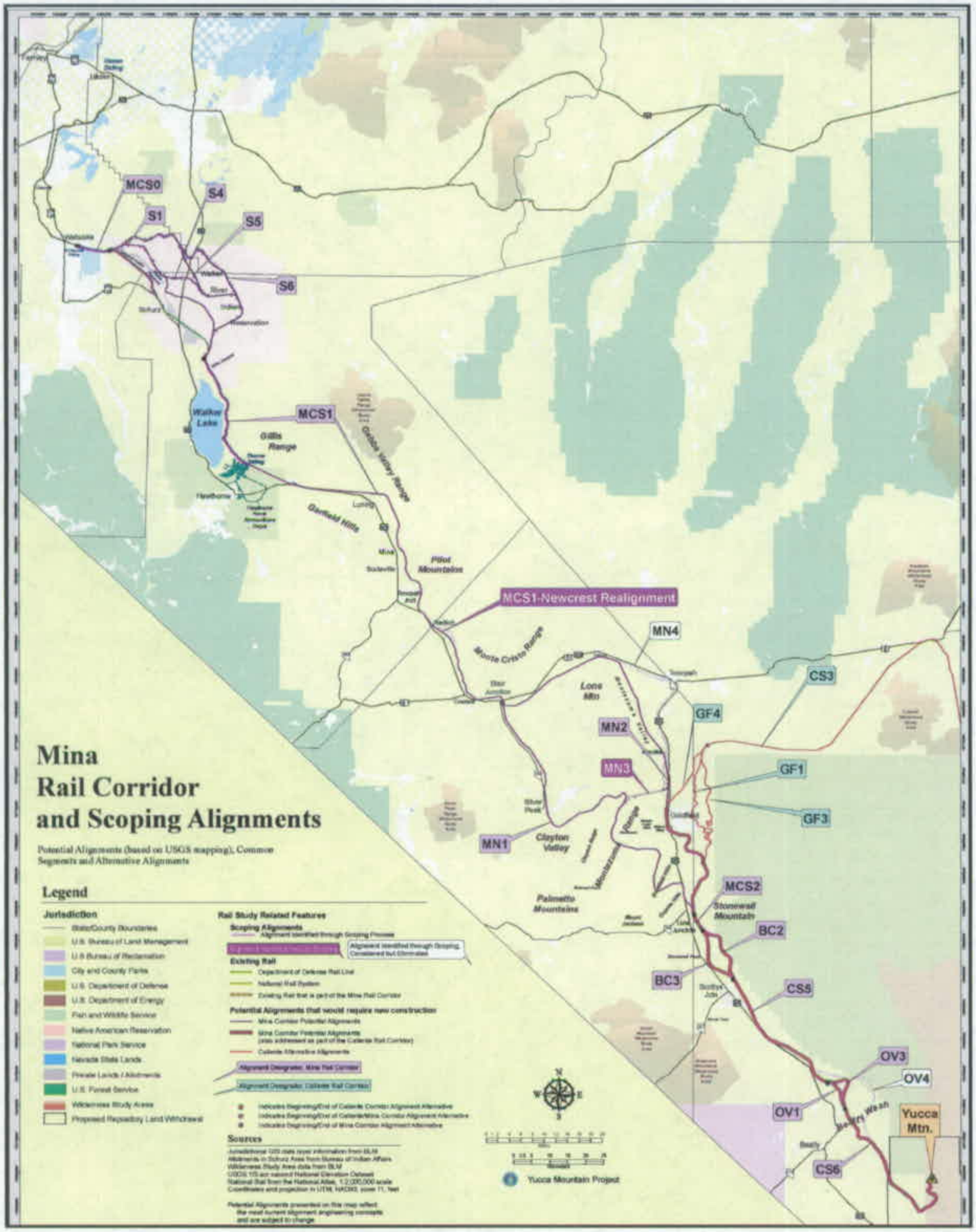

Figure B-2. Mina Rail Corridor and Scoping Alignments

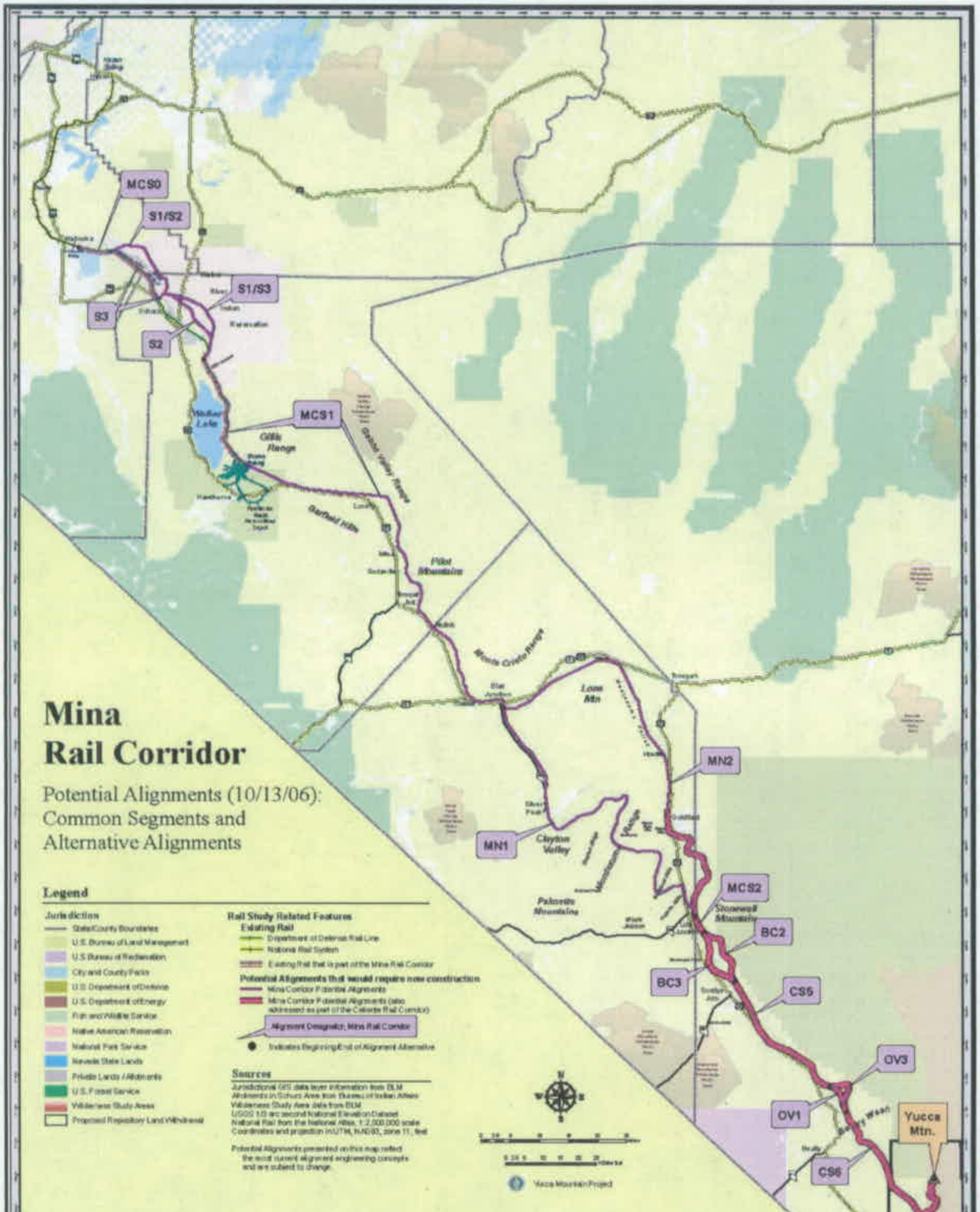

Figure B-3. Mina Rail Corridor – Potential Alignments

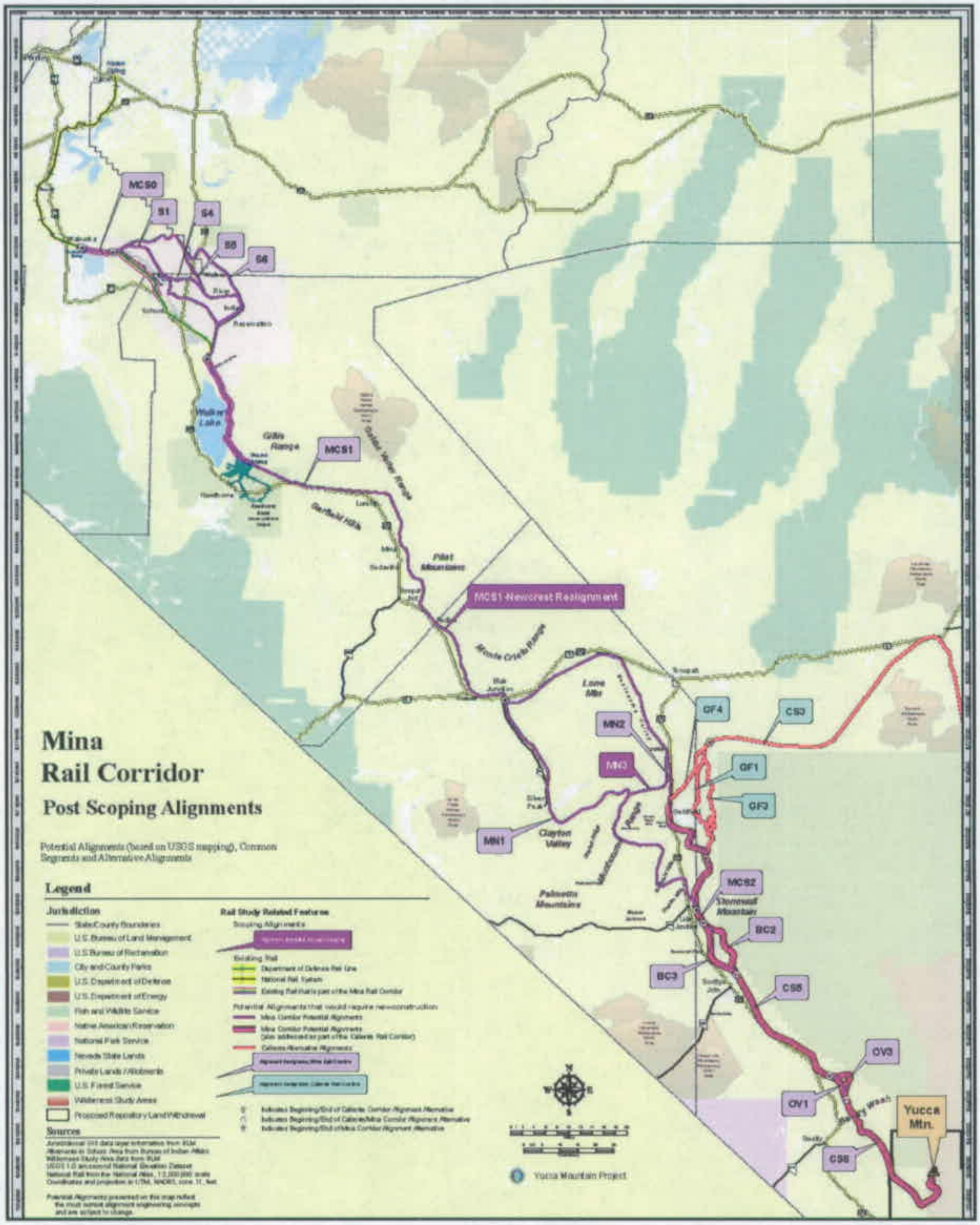

Figure B-4. Mina Rail Corridor – Post Scoping Alignments